Simulation of massive persistent sensor networks

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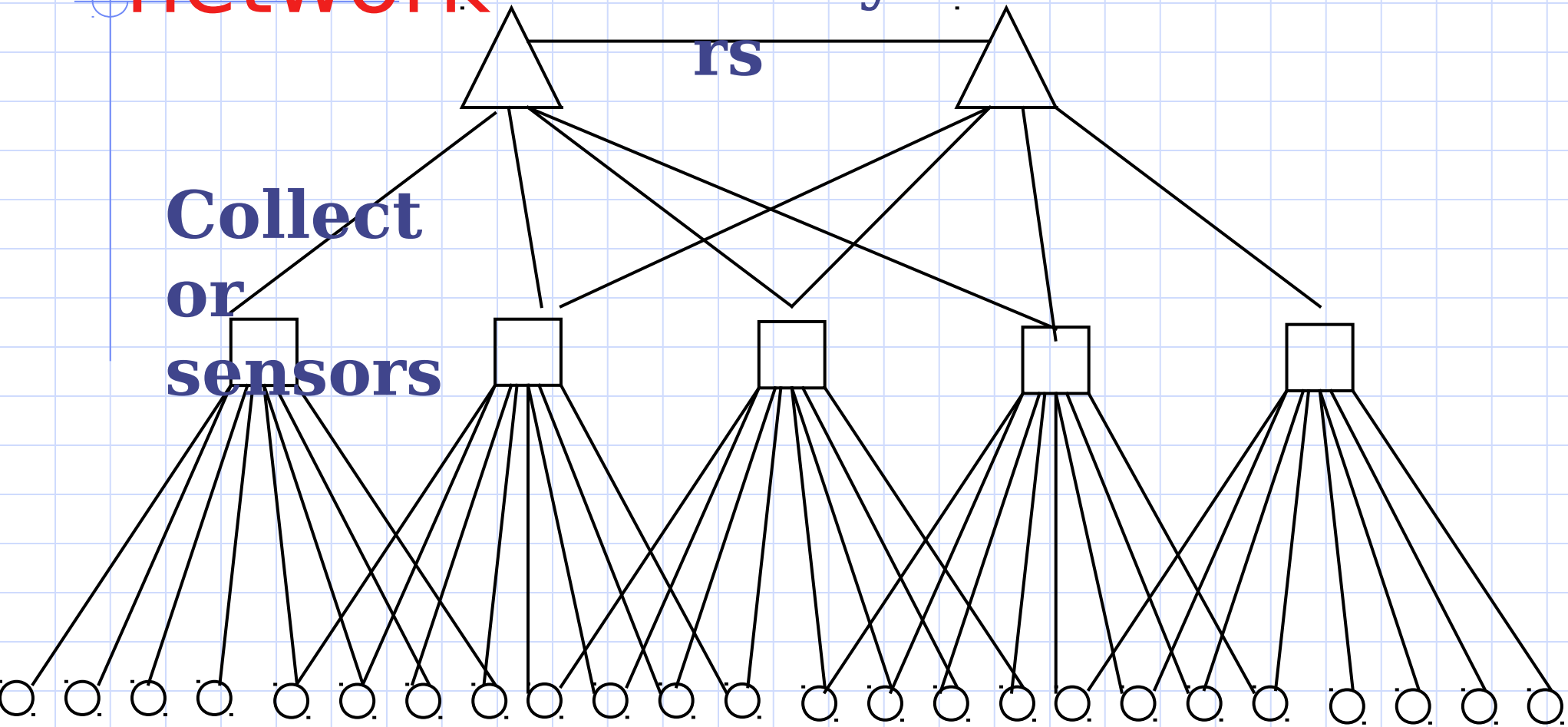
Changing sensor technology

- Microsensors are getting smaller and smaller -- think of dispersing millions of sensors in a battlespace (land, water, or air).
- New sensor types: chemical, biological, nuclear. So networks will be nonhomogeneous.
- Then the problems are: (1) finding the sensors; (2) wireless communications; (3) self-organization.
- A nice idea: many small primitive low-powered sensors plus a few sophisticated high-power "data collectors".

Traditional sensor network



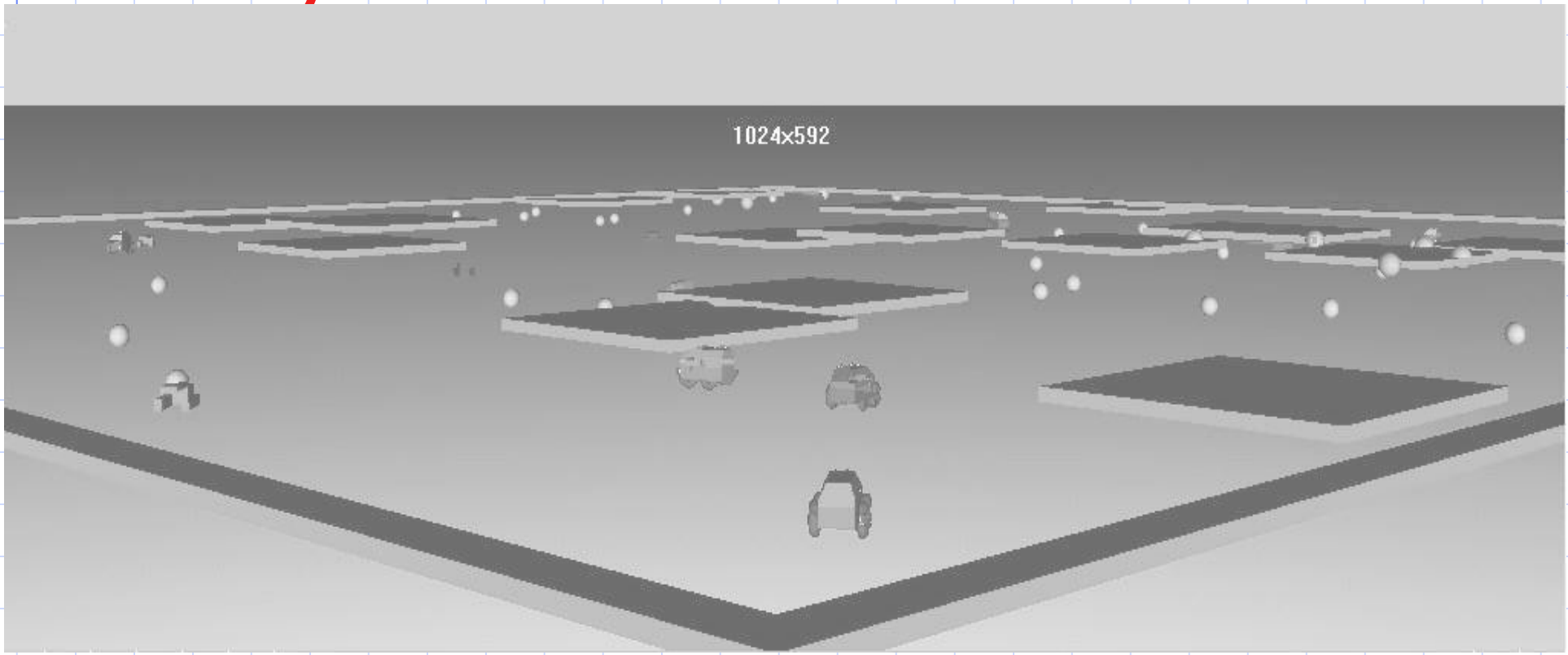
Simulation is important for researching sensor networks

- It’s too hard to build real million-element or billion-element networks.
- We can compare millions of implementations easily in a simulation.
- We can explore self-organization ideas easily.

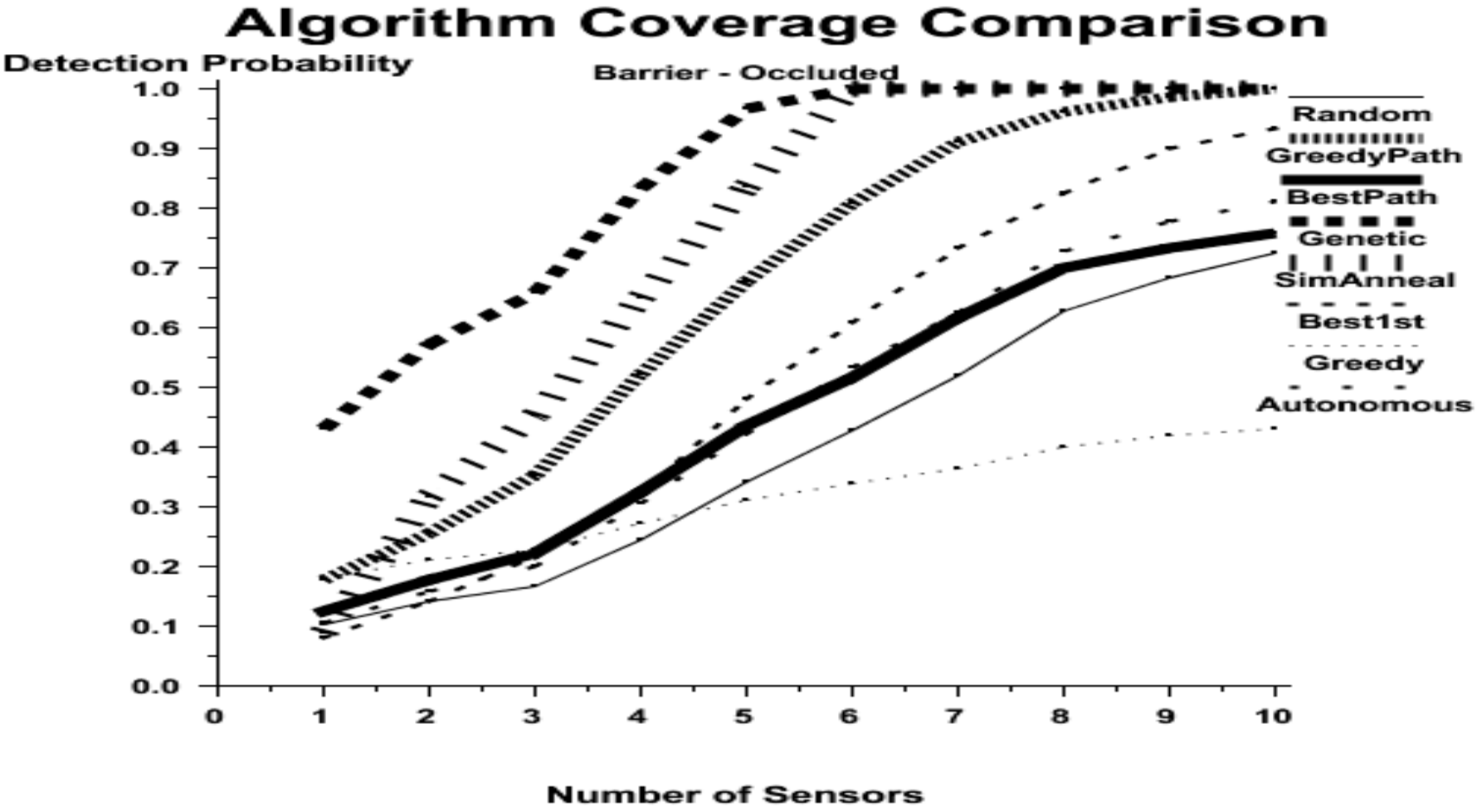
Sensor network setup

- Randomly disperse small sensors (throw out of aircraft, etc.)
- Sensors can be located by sending targets through the sensor field and noting reports.
- Communications can be reduced by reporting only changes.
- Communications can be done by sounds, lights, and chemicals besides radio – will fool enemies better.

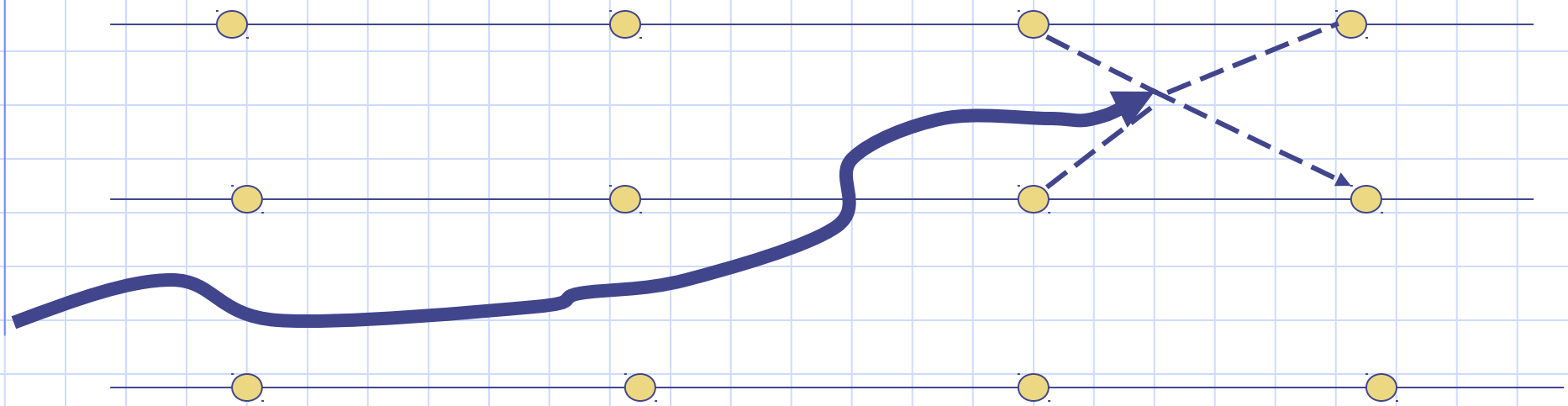
Sensor network from the Hynes thesis



Placement algorithms



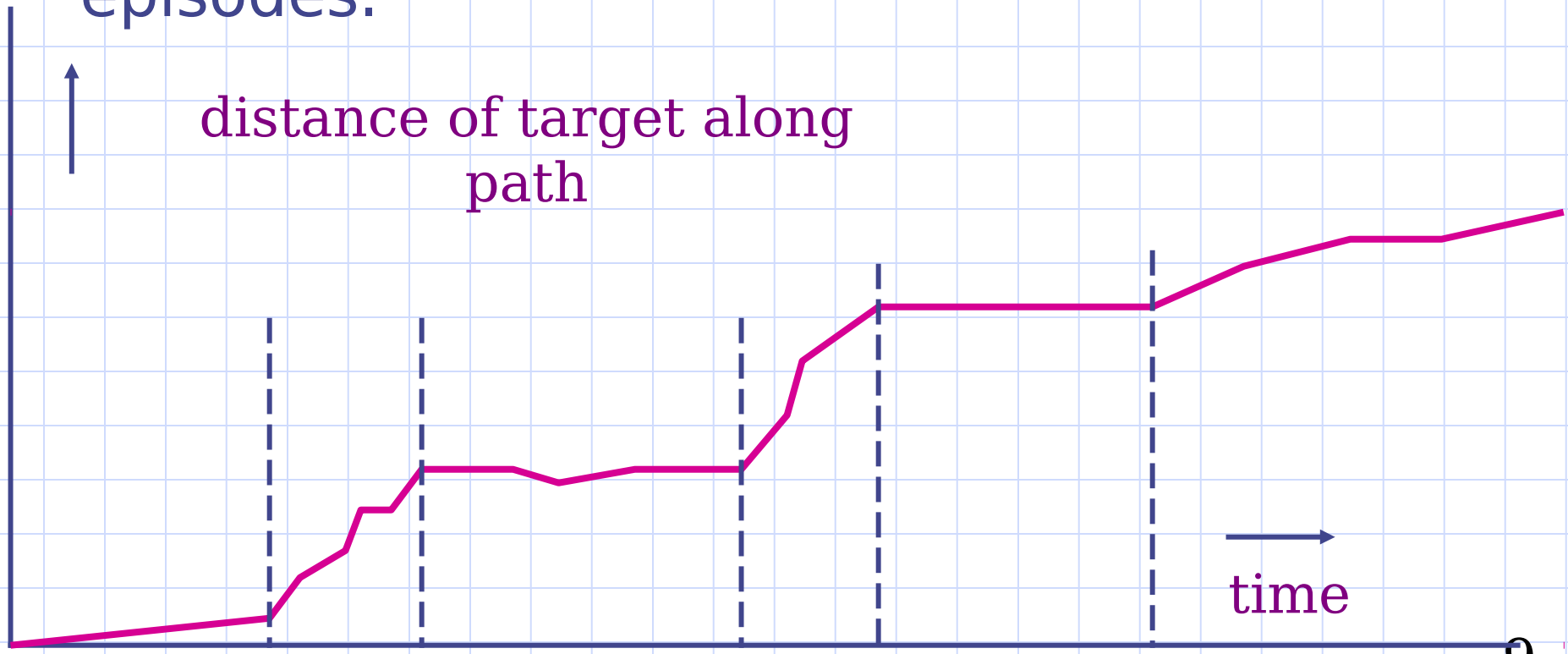
Tracking an intruder with connected sensors



For nondirectional sensors, one can triangulate from three signal strengths by solving 3 equations in 3 unknowns.

Analyzing moving targets

- Project paths as function of time onto a single dimension, cluster to find behavioral episodes.



Inferring suspicious behavior

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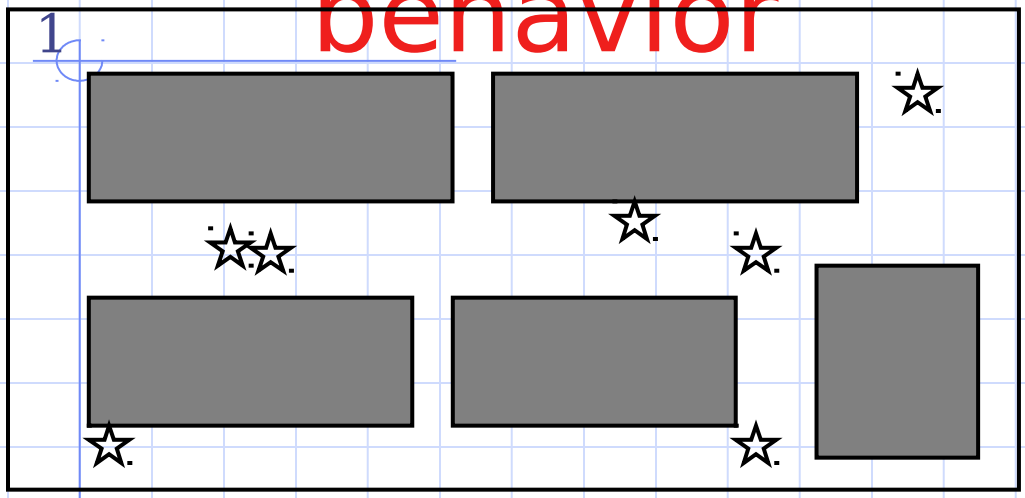
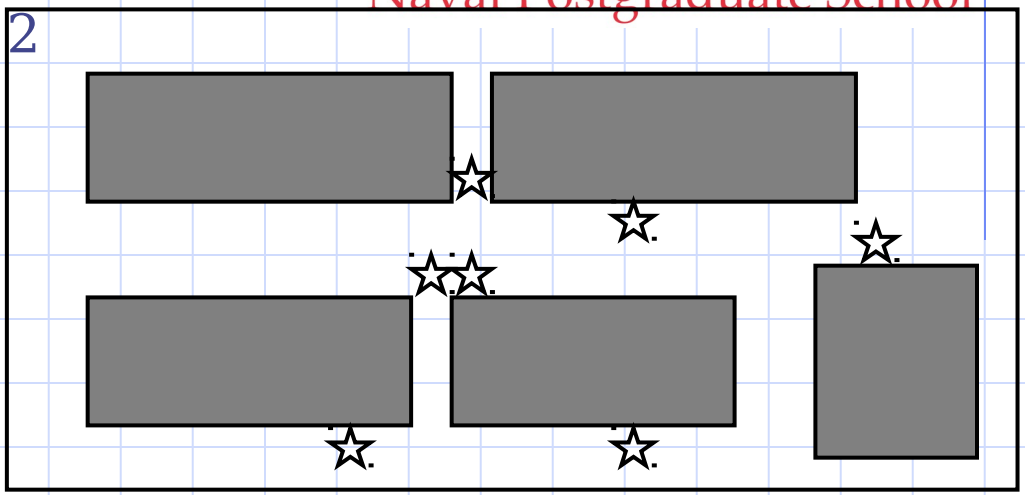
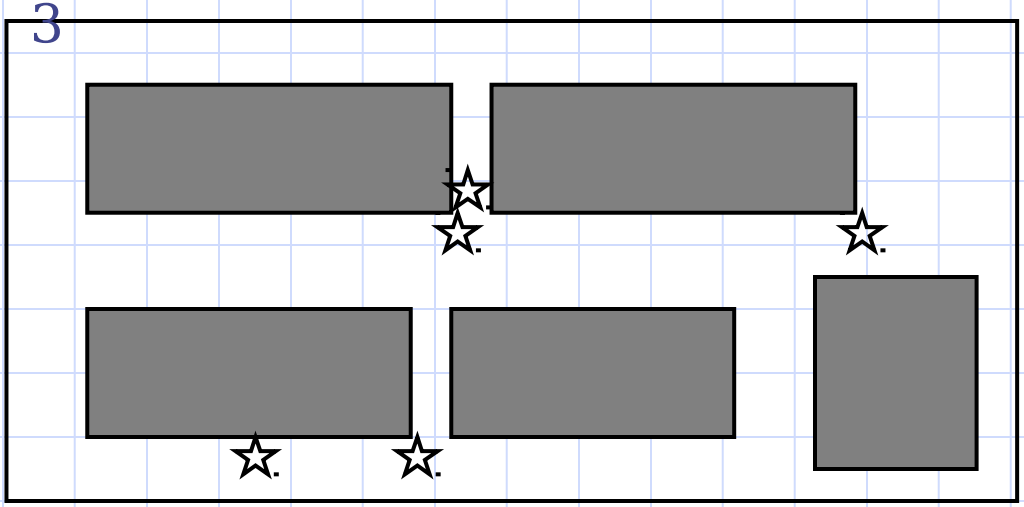
Snapshot 1



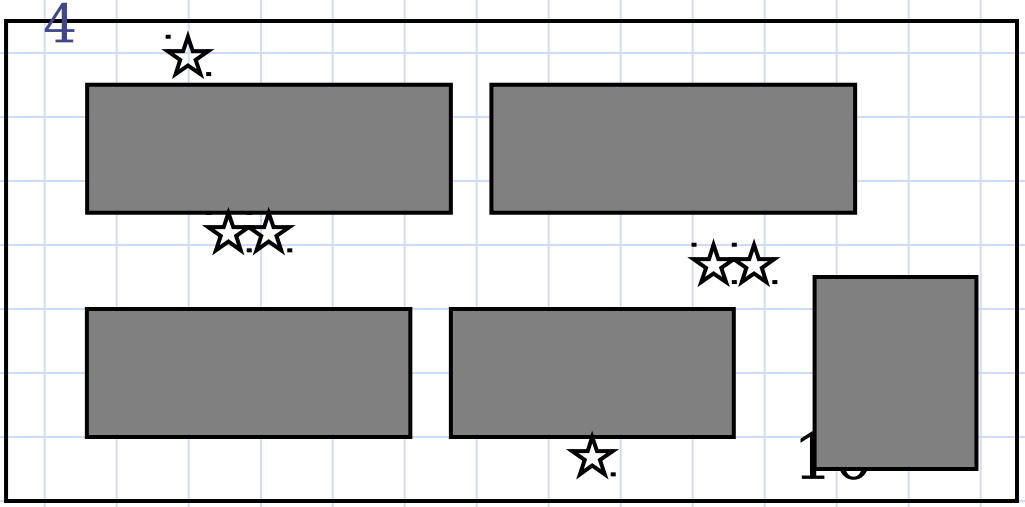
Snapshot 2



Snapshot 3



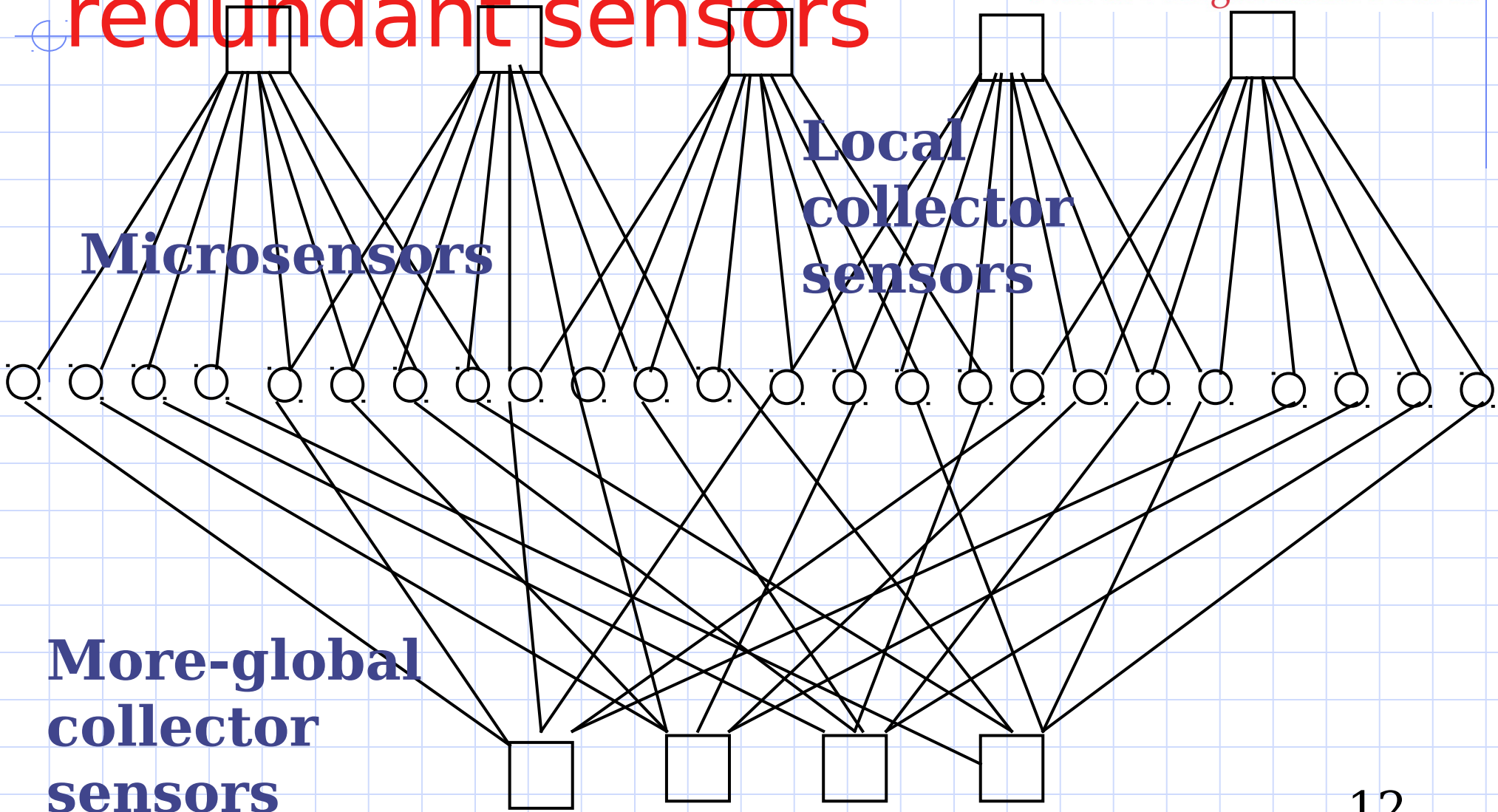
Snapshot 4



Self-organizing networks

- Military-setting processing load can vary greatly.
- Load balancing is helps as well as redundancy.
- Overloaded collector sensors can broadcast load-sharing requests.
- With a persistent imbalance, streamlined communications channels can be created, amounting to a new hierarchy.

The advantages of redundant sensors



Additional issues

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- How does irregular terrain affect the communications of the sensors?
- What if the entire sensor network moves, as in a convoy?
- How many sensors does the enemy need to destroy to significantly hurt us?
- Can deception confuse the enemy as to where our important sensors are?